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Research article

Emotional simulations and depression diagnostics

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ABSTRACT

In this work we propose the following hypothesis: the neuromodulatory mechanisms that control the emotional states of mammals can be translated and re-implemented in a computer by controlling the computational performance of a hosted computational system. In our specific implementation, we represent the simulation of the 'fear-like' state based on the three dimensional neuromodulatory model of affects, in this paper 'affects' refer to the basic emotional inborn states, inherited from works of Hugo Lövheim. Whilst dopamine controls attention, serotonin is the key for inhibition, and fear is a elicitator for inhibitory and protective processes. This inhibition can promote [in a cognitive system] to blocking behaviour which can be labelled as 'depression'. Therefore, our interest is how to reimplement biomimetically both action-regulators without the computational system to resulting in a 'failed' scenario. We have simulated 1000 ms of the dopamine system using NEST Neural Simulation Tool with the rat brain as the model. The results of the simulation experiments are reported with an evaluation to demonstrate the correctness of our hypothesis.

1. Introduction

The current rapid developments in neurocognitive sciences and new discoveries related to the core mechanisms of natural intelligence have triggered new insights and opportunities in the field of biologically inspired cognitive systems. There are new and reliable data related to a key aspect [previously undervalued or hidden] which builds the entire cognitive processes architecture: emotions (Minsky, 2007).

Research has shown that emotions play a significant role in natural intelligence and adaptive behaviour (Damasio, 1999; Picard, Vyzas, & Healey, 2001). Additionally, the intrinsic value of emotions in cognitive processes remains undervalued by researchers who take a behaviourist approach to artificial emotions based on basic observable actions; we term this: *the 'skinnerian' approach to emotions*. This approach basically considers the emotional performance as *epiphenomenalist* without considering the deep mechanisms that are hidden under this black box. This view can be somehow useful for 'real-time' emotional detection during Human-Robot Interactions or Human-Computer Interactions.

Attempts to design computer emotional architectures have been proposed, consider for example *CogAff* (Sloman, 1994) or *LIDA* (Franklin, Madl, D'Mello, & Snaider, 2014) which are architectonically modulatory and whilst they simulate the homeostatic role of emotional mechanisms, they fail to provide an integrative way to implement emotional design into all areas of computational activity.

As a departure point of our model, we consider a simple "fear", which is necessary to evaluate "fly-or-fight" actions (Stevenson & Rillich, 2012). Our study focuses on two opposing and complimentary neuromodulators: dopamine and serotonin (Daw, Kakade, & Dayan, 2002). Dopamine is related to brain reward processes, whilst serotonin is implied into aversive or inhibitory processes; used in combination we may design a system that manages 'fly-or-fight' actions in which several learning procedures could be easily implemented.

We argue that our proposal represents a milestone in the creation of a new generation AI intelligence incorporating the capability to create neuromodulatory architectures which can run over several conceptual models, languages and systems. The posited

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